III. OBJECTIVE

In view of this question, GIPSA's Ft. Worth field office has conducted a preliminary investigation of fed cattle procurement in the Texas panhandle. GIPSA has interest in determining whether procurement of cattle by packers during the period of the investigation is associated with potentially unfair, unjustly discriminatory, or deceptive practices to the detriment of livestock producers. Because of the complex interrelationships among the factors that determine prices paid for cattle, econometric analysis is needed to obtain defensible conclusions about the potential effects of various procurement practices on prices. The research reported here provides such analysis and was carried out in fulfillment of Cooperative Agreement No. 98-PPD-01, "Econometric Analysis of Fed Cattle Procurement in the Texas Panhandle," USDA, GIPSA.

GIPSA has particular interest in determining whether packers' non-cash purchases of fed cattle affect transaction prices, as results from prior research have been equivocal. Thus, the objective of this project is to measure the use and effects of non-cash purchases on prices paid for fed cattle during the period of the investigation.

IV. BACKGROUND, MOTIVATION, AND SPECIFIC OBJECTIVES

Issues concerning the relationship between packers' use of non-cash procurement methods and the spot market price of cattle can be separated into two categories: long-run issues and short-run issues. Long-run issues have to do with the relationship between spot market price and the overall proportion of annual fed cattle slaughter that is attributable to non-cash procurement methods. An understanding of these issues would be required to predict how the spot market would likely be affected if packers' degree of reliance on non-cash cattle sources were to continue to increase, or if currently practiced non-cash procurement methods were to be prohibited or severely restricted by law. Short-run issues, on the other hand, have to do with the spot market price impact of packers' and feeders' decisions about the number of non-cash cattle to deliver to plants in a given week. An understanding of this relationship would be needed to determine whether short-run supply sourcing strategies can be used to manipulate spot market price.

The data collected in GIPSA's Texas Panhandle investigation represent the activities of only four plants and span a relatively short time period (from the week of February 5, 1995 through the week of May 12, 1996) in which there was no change in the institutional arrangements governing the use of non-cash procurement methods and

little or no evident trend in the actual overall use of these methods.[1] Consequently, these data are of limited use for the investigation of long-run issues. The data are well-suited, however, to the investigation of short-run issues concerning the relationship between the use of cattle procured by non-cash methods and spot market prices on a week-to-week basis.[2] For this reason, the econometric analysis undertaken in this report will focus on short-run issues.[3]

In spite of this report's primary focus on short-run issues, we will briefly review the two most recent theoretical models of the long-run effects of non-cash procurement on spot market prices.[4] For reasons explained above, the Texas Panhandle data is not suited to what we would consider to be a serious test of these theories, but they can provide what amounts to anecdotal evidence bearing on the theories' applicability to the Texas Panhandle fed cattle market.

Love and Burton develop a model of a food processor (a beef packer, for example) that exercises monopsony power in its raw input (cattle) market. Adapting

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[1]For the four plants combined, and for the sample period as a whole, the proportions of steer and heifer slaughter attributable to each of the procurement methods were 5.24% for forward contract, 2.48% for packer fed, 21.00% for marketing agreement, and 71.29% for spot market. The corresponding proportions calculated separately for the first and second halves of the sample period were little different from the figures for the entire sample period: First half: 5.20% for forward contract, 2.59% for packer fed, 21.94% for marketing agreement, and 70.27% for spot market. Second half: 5.28% for forward contract, 2.35% for packer fed, 20.00% for marketing agreement, and 72.37% for spot market.

[2]The sample's proportions of weekly steer and heifer slaughter attributable to each of the procurement methods did show significant variation over the sample period. For example, the proportion of weekly steer and heifer slaughter attributable to forward contract cattle ranged, over the sample's 67 weeks of data, from a low of 0% to a high of 30.55%. The corresponding figures for the other procurement methods were; for packer fed cattle: low = 0.17%, high = 6.81%; for marketing agreement cattle: low = 8.96%, high = 31.95%; and for spot market cattle: low = 42.11%, high = 88.88%.

[3]Our investigation of the short-run relationship between deliveries of non-cash cattle and spot market prices will, however, have implications about the credibility of commonly-made claims regarding long-run issues. In particular, we will address whether the negative correlation between non-cash cattle deliveries and spot prices that is frequently found in weekly data is evidence that legal restrictions on the use of non-cash procurement methods would lead to an increase in spot market prices.

[4]We are grateful to Professors H. Alan Love and Richard Sexton for bringing these models to our attention.

and extending an analysis due to Perry, Love and Burton first show that the processor has a profit incentive to vertically integrate "upstream" into raw input supply, either through acquisition of some of the previously independent producers or through the exercise of some sort of vertical control, such as marketing agreements or long-term contracts of other kinds. This incentive arises because, in an unintegrated monopsony equilibrium, the market price of the raw input understates its marginal value to the processor.[5] The result is a production inefficiency: Too little of the input is used. By extending partial vertical control over input supply, the processor can internalize some of this efficiency loss while continuing to exercise monopsony power over the remaining, unintegrated suppliers.

Love and Burton's model yields no unambiguous conclusions about the effects of upstream vertical integration on spot market price, however. Without additional assumptions about the elasticity of supply by independent producers, the model could be consistent with a spot market price that increased, decreased, or remained unchanged with decreases in the proportion of input supplies procured on the spot market. One implication of their analysis is that the price paid to the input suppliers that are under the processor's vertical control (feeders with marketing agreements, for example) will, however, be higher than the price paid to independents in the spot market. Love and Burton cite Ward *et al.* for evidence that packers pay higher prices for cattle procured through marketing agreements than for cattle purchased in the open market. Similar evidence can be found in the Texas Panhandle data analyzed in this report.[6]

Zhang and Sexton develop a model of processor/input supplier interaction that takes explicit account of the spatial aspects of the market. In their model, two processors (rival packers, for example) purchase raw input (cattle) from a large number of independent producers (feedlots) that are spatially distributed in a market modeled as a line segment. Zhang and Sexton show that, by offering long-term contracts to suppliers near the boundaries of market areas, the processors can create a geographic buffer between them, enabling the exercise of a greater degree of monopsony power

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[5]The processor cannot exploit this divergence between price and marginal value because, without the ability to price discriminate, purchasing more input would require paying a higher price on the inframarginal as well as the marginal units purchased. The incremental cost of increasing input usage by one unit would exceed the market price of the input.

[6]In section VI.2, we report evidence that all four plants paid higher quality-adjusted prices for marketing agreement cattle than for spot market cattle and that the plant paid higher quality-adjusted prices for forward contract cattle than for spot market cattle.

over the remaining independent suppliers. In this scenario, the use of long-term contracts is a manipulative tactic that enables processors to benefit at input suppliers' expense.

The simplifying assumptions of the Zhang and Sexton model (only two competing processors; a geographic market area that is isomorphic to a one dimensional line segment) are necessary for analytical tractability, but they do make it somewhat difficult to translate their results to real-world market settings. If the Zhang and Sexton story captures the essence of packers' motivation for using non-cash procurement methods, it does seem clear, however, that we should see non-cash cattle being drawn from the "boundary" regions of each plant's market area. Under these circumstances, it seems likely that non-cash cattle would tend to be shipped farther on average than spot market cattle. Table IV.1 reports summary statistics, by plant and by procurement method, for the distributions, across lots of fed cattle, of the distances (in miles) that cattle were shipped to the plant. In every one of the four plants, the cattle lot shipped the farthest, among all lots, was purchased on the spot market. Moreover, in numerous instances, spot market lots were shipped farther on average than lots acquired by other methods. For spot market lots were shipped farther on average than marketing agreement lots and packer fed lots. For spot market lots were shipped farther on average than forward contract lots and marketing agreement lots. For spot market lots were shipped farther on average than forward contract lots and marketing agreement lots. And, for spot market lots were shipped (slightly) farther on average than packer fed lots. These features of the Texas Panhandle fed cattle market appear to be inconsistent with the predictions of the Zhang and Sexton model.

In the context of the Zhang and Sexton model, the strategic role of the "buffer" region of suppliers under long-term contract is to make it unprofitable for processors to "jump" the buffer and compete directly with a rival in the rival's spot market territory. So another *ad hoc* "test" of the applicability of the Zhang and Sexton model can be carried out by calculating the proportion of spot market purchases of fed cattle that were made from a supplier located closer to one or more of the rival packers' plants. Among the lots of fed cattle purchased on the spot market by the Excel-Friona plant, were purchased from feeders located closer to the IBP or Monfort plants than to Friona. For the Excel-Plainview plant, of spot market fed cattle purchases were from feedyards closer to IBP or Monfort. For the IBP and Monfort plants the proportions of spot market purchases from feeders closer to one or more of the other three plants were respectively. It appears, from these figures, that packers relatively frequently compete directly with rivals in the rival's spot market territory. To this extent, the stylized facts of the Texas Panhandle fed cattle market are not consistent with the Zhang and Sexton model.

Previous attempts by agricultural economists to econometrically estimate and explain the effect of non-cash purchases on fed cattle prices span over thirty years. From Aspelin and Engelman (1966) to Azzam (1996), there have been several studies

including Hayenga and O'Brien (1990, 1991, 1992), Schroeder, *et al.* (1991a, 1991b, 1992, 1993), and Ward *et al.* (1996). Though the studies differ in terms of units of observation,[7] data frequency, sample period, and econometric method, they share a common objective: To estimate the impact on the spot market price paid to independent cattle feeders of an increase in non-cash purchases, expressed in terms of either the number of head slaughtered or the proportion of total slaughter attributable to non-cash purchases. More recent studies have gone a step further and attempted to estimate the relationship between spot market price and non-cash purchases simultaneously with relationships explaining packer's contemporaneous decisions to deliver forward contract, marketing agreement, or packer fed cattle to the packing plant (Ward, *et al.*).

In our judgment, what the literature has been able to provide so far is evidence of an empirical regularity that, using Schmalensee's language, is more useful in describing how the market *looks*, rather than explaining how it *works*. The empirical regularity is that the contemporaneous level of non-cash purchases, expressed either in absolute levels or as a proportion of slaughter, has a small, negative, and sometimes statistically significant relationship with spot market cattle prices.

What to make of the negative relationship depends on what the analyst posits as the economic mechanism behind it. Assuming, for the moment, that spot market cattle prices are competitively determined by the forces of supply and demand, one's first instinct is to think of the impact of non-cash purchases in terms of shifts in the short-run supply and demand curves for fed cattle. As outlined by Ward, *et al.*, non-cash procurement of cattle has the effect of shifting to the left both the supply and demand for fed cattle in the cash market. The shift in supply is due to reduced availability of cash cattle, and the shift in demand is caused by less aggressive bidding by packers who have assured some of their slaughter needs through non-cash purchases. But if a given increase in the volume of non-cash purchases were to shift spot market supply and demand by equal amounts, as seems plausible, the spot market price would be left unchanged. This leads some to attribute the observed negative correlation between spot price and the use of non-cash procurement methods to non-competitive pricing conduct on the part of packers. But Azzam (1998) has shown, using a model more sophisticated than the simple supply and demand analysis outlined above, that a negative contemporaneous relationship can emerge in a market characterized by competitive packer conduct as well.

In this report, we will first confirm, in section VII, that the negative correlation between the use of non-cash procurement methods and spot market price found by others using their data, is present in our data too. Then, in section VIII, we will suggest

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[7]In some studies the unit of observation was the price of different pens of cattle; in others, the unit of observation was the average fed cattle price in major cattle feeding states.

economic mechanisms that might be responsible for these empirical relationships. In this effort, we will be very careful to distinguish between two kinds of relationships that are very different, both in their empirical manifestations and in their plausible economic causes: 1. The relationship between the relative degree of reliance on non-cash procurement methods by a given plant and the spot market prices paid by that plant *relative to the regional market's average price.* (studied in sections VII.1 and VIII.1), and 2. The relationship between the use of non-cash procurement methods at the regional level and the regional average spot market price (studied in sections VII.2 and VIII.2).

In section IX we investigate one particular institutional arrangement that might create the opportunity and incentive for abusive pricing conduct by packers. That possibility has to do with the nature of the base price in the formulas used to price marketing agreement cattle. In some cases, the base price for formula-priced cattle delivered this week is derived from the plant's average hot cost last week. Do we see evidence, in these cases, that packers attempt, through their spot market pricing conduct, to manipulate the formula base to their advantage?

Section X will summarize our findings on these issues and present our recommendations.

Before we can investigate these issues, however, some important questions about the determination of the volume and timing of deliveries of cattle procured by non-cash means, largely ignored in previous analyses, must be addressed. Who is responsible for deciding how many non-cash supply cattle will be delivered to the plant within any given time period? How far in advance of delivery is this determination made? The answers to these questions will be reflected in certain aspects of the econometric analysis presented in this report. The next section, section V, will provide an overview of the data and then address these key modeling issues.

Again, the report's main line of inquiry concerns the relationship between non-cash procurement methods and spot market price. As a preliminary to this main inquiry, section VI will use multiple regression analyses to conduct investigations of the differences between cattle purchased on the spot market, on the one hand, and cattle procured by each of the three non-cash procurement methods (marketing agreement, forward contract, and packer fed), on the other. Specifically, two questions will be addressed: Are there quality differences among cattle procured by different methods? And, are there quality-adjusted price differences among cattle procured by different methods?

V. DATA AND ASSUMPTIONS

The primary data set used in this study was collected by GIPSA. It provides a nearly complete record of cattle procurement activities for four large beef packing plants in the Texas panhandle region over the period from early February 1995 through mid-May 1996. The plants are the Excel plant at Friona, the Excel plant at Plainview, the IBP plant at Amarillo, and the Monfort plant at Cactus. The primary data set includes information on every lot of cattle, of over 35 head, purchased by the four Texas plants during the period of investigation. A complete listing of the types of information available for each of these lots is presented in Appendix A.

Certain parts of the analysis required supplementary data on regional average steer and heifer prices, boxed beef cutout values, Chicago Mercantile Exchange live cattle futures prices, and other variables. These were compiled, from standard published sources, either by GIPSA or by the authors of this report.

The three types of non-cash procurement methods (listed in decreasing order of importance for the four Texas plants) are marketing agreement cattle, forward contract cattle, and packer-fed cattle. Marketing agreement cattle were by far the largest non-cash source for the four Texas plants over the period of investigation. Tables V.1 and V.2 report the volumes of marketing agreement deliveries of steers and heifers, on a plant-by-plant basis, expressed as percentages of total non-cash purchases, and of total slaughter, respectively. As part of their investigation, GIPSA personnel interviewed feedyard owners and managers about various aspects of live cattle markets including the terms of their marketing agreements with packers. From our review of the reports of these interviews, the following assumptions seem warranted:

1. For the most part, the number of cattle to be delivered by a feeder, to a plant, under a given marketing agreement, within a given week, is determined by the feeder. In some cases, it appears that packers may occasionally amend the delivery numbers submitted by feeders.

2. The number of marketing agreement cattle to be delivered by a feeder within any one week is normally determined two weeks in advance of delivery.[8]

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[8]In making the judgment that the volume of marketing agreement deliveries is "normally" determined two weeks in advance of delivery, we are relying on our interpretation of the company documents and interview reports summarized in Appendix B, not on the data. For marketing agreement lots, the data contain information about the "scheduling date," the date on which the packer decides the particular day of delivery, not the earlier "notification date," the date on which the feeder decides on the number of cattle to be delivered during a given week.

3. Once the volume of marketing agreement deliveries for a given week is set (normally by the feeder), the packer has discretion over the specific day or days of the week upon which delivery will be made.

Appendix B provides support for these assumptions in the form of several excerpts from company documents and from reports of interviews with feedyard personnel.

Forward contract cattle were the second most important non-cash source of steers and heifers for the four Texas plants. Again, Tables V.1 and V.2 show their significance, on a plant-by-plant basis, relative to total non-cash supply volume and to total slaughter. standard basis forward contract (which we assume to be typical of basis forward contracts used by other packers) stipulates that "The cattle shall be delivered *on a day designated by Buyer* during the delivery month, or by mutual agreement at an earlier or later date." (emphasis added) Anecdotal evidence suggests, however, that delivery timing is usually a mutual decision between the buyer and the feedlot, with an effort made to deliver cattle when their optimal potential is reached. We assume that the timing of forward contract cattle delivery is determined primarily by the packer. Once the decision to deliver is made, there can be a time lag attributable to delays in arranging for transportation. We assume that the number of forward contract cattle to be delivered in a given week is normally decided either one or two weeks in advance.[9]

Our data identifies lots of cattle purchased on forward contracts but contains no information on which lots were purchased on basis forward contracts and which (if any) were purchased on fixed price contracts. Certainly the vast majority (perhaps even all) of the forward contract cattle in the sample were purchased on basis forward contracts. Ward, *et al.* describe this type of contract form:

"A packer bids a futures market basis for the month cattle are expected to reach slaughter weight and finish. The feeder then has the option of determining when

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[9]In making the judgment that the number of contract cattle to be delivered in a given week is "normally" determined one or two weeks in advance, we are relying on the data. For contract lots, the data usually contain the "scheduling date," the date on which the lot's delivery date is fixed by the packer. For these lots, the distribution of the number of days from the scheduling date until the kill date has a mean of 11.88 days and a standard deviation of 7.98 days. One possible scenario for a "typical" contract lot, therefore, is that it is scheduled on Monday of one week and delivered on Saturday of the following week, 12 days hence. More likely, however, the weeks of scheduling and delivery dates for a typical lot will not be consecutive but will be separated by an intervening week. One further complication: In some cases, the date recorded as "scheduling date" for contract cattle was actually the contract date because the scheduling date was not available. These cases were not identified in the data, nor can their identities be inferred with certainty.

> to price the cattle (i.e., select a futures market price). From that futures market price, a cash selling price is computed, based on the agreed-upon basis. . . . For example, assume that after the basis contract is signed, a cattle feeder believes the futures market price for the specified contract month has peaked. The cattle feeder notifies the packer and chooses the then-current futures market price, thereby also determining the cash sale price, based on the previously agreed basis bid."

The provision of the contract which covers price determination reads:

> "All basis price cattle shall be priced by Seller by notifying Buyer prior to the first day of the month of the live cattle futures price applicable to the transaction or the first day of the month the cattle are projected to finish, whichever is earlier, If Seller fails to set the futures price, Buyer will set the price on the last day of the pricing period by executing, or having the ability to execute, a trade within the closing trading range on the Chicago Mercantile Exchange (CME)."

Thus, by the time the delivery month arrives and the packer comes to the point of deciding how to allocate the contract's number of head across the delivery month's weeks, forward contract cattle represent a fixed-price supply source.

During the period of investigation, packer fed cattle were not used at all by constituted only a very small share of slaughter for the but did represent a significant percentage of all steers and heifers killed by (Table V.2) Obviously, the packer has complete discretion over when to utilize packer-owned supplies of cattle.

With these assumptions in mind, the analysis will proceed as follows. In section VII, we explore, in a manner similar to previous efforts, the empirical relationship between non-cash supplies and spot market prices at both the plant and regional levels. After that, in section VIII, we address the issue of what possible economic mechanisms could be behind the empirical relationships at both levels. Section IX addresses the influence of the base formula price on spot market pricing conduct. Section X summarizes the findings and offers some conclusions and recommendations.

VI. ARE THERE SYSTEMATIC DIFFERENCES AMONG CATTLE PROCURED BY DIFFERENT METHODS?

In this section, we make a preliminary investigation of the differences among cattle procured in different ways. In particular, we inquire as to whether cattle procured by the four different methods (spot market, contract, marketing agreement, and packer

fed) display systematic differences in quality and in quality-adjusted price.[10] The answers to these questions are fundamental to an understanding of packers' incentives to use non-cash procurement methods. The quality issue, in particular, is of interest because of the wide-spread perception that cattle procured via marketing agreements, the largest non-cash procurement source in the GIPSA data, are of higher quality than spot market cattle.

VI.1. Quality Differences

There are several dimensions of the quality of a lot of fed cattle including yield, quality grade, yield grade, sex, and average carcass weight. Two other lot characteristics which can influence the price of the lot are the size of the lot (number of head) and the distance the lot must be shipped to the plant. One can get a preliminary idea of how these factors vary by procurement method by examining the summary statistics presented in Table VI.1.1. For each plant, and for each procurement method used by the plant during the sample period, the table reports the following statistics:

the total number of lots;
the proportions of steer lots, heifer lots, and mixed steer and heifer lots within this total;

and the sample mean and standard deviations of (variable name, units):

the number of cattle in the lot (HEAD, head);
the lot's total hot weight divided by total live weight (YIELD, %);
the percentage of cattle in the lot grading prime or choice (PCTPC, %);
the percentage of cattle in the lot achieving yield grades 1, 2, or 3 (PCTYG13, %);
the distance the cattle were shipped to the plant (MILES, miles);
and the lot's average carcass weight for steer, heifer, and mixed lots separately (lbs.).

A casual comparison of these statistics across procurement methods within a given plant supports the following generalizations:

> For all four plants, marketing agreement purchases contain a higher proportion of steer lots and have at least a slightly higher yield, on average, than lots procured by the other three methods.
>
> For all four plants, the indicator of yield grade (PCTYG13) varies relatively little on average, across procurement methods, but in three of the four plants the average value of PCTYG13 is higher for marketing agreement cattle than for the other procurement methods.

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[10]We are grateful to Professor DeeVon Bailey for suggesting that these analyses be incorporated in this report.

In the indicator of quality grade (PCTPC) is lower, on average, for marketing agreement cattle than for the other three procurement methods. In average quality grade is lower for contract cattle than for the other three procurement methods. In average quality grade is higher for spot cattle than for the other three methods. In there is little variation in quality grade across procurement methods.

In average carcass weight is higher for spot cattle than for contract and marketing agreement cattle. In average carcass weight is higher for marketing agreement and packer fed cattle than for spot and contract cattle. In average carcass weight is higher for marketing agreement cattle than for the other three sources; while in it is higher for packer fed cattle than for the other three procurement methods.

In the sample of packer fed lots appears to be more uniform in quality characteristics than the samples of lots procured by each of the other three methods. For this plant, the standard deviations of the distributions, across lots, of YIELD, PCTPC, PCTYG13, and average carcass weight for steer lots are all lower for the packer fed sample than for the spot, contract, and marketing agreement samples. It should be noted, however, that these summary statistics are based on only 15 packer fed lots slaughtered at the during the period of investigation. In the other three plants, it is often the sample of spot market lots that appears to be the most uniform. In the following cases (quality characteristic - plant) the standard deviation is lower for spot market lots then for each of the other procurement methods: PCTPC - PCTYG13 - average carcass weight in steer lots - average carcass weight in heifer lots - .[11]

When, as in this case, the "quality" of a commodity is multi-dimensional, one can construct a scalar index of quality through estimation of a function that explains price in terms of product characteristics.[12] In our application of this methodology, we start with

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[11]It should be emphasized that the standard deviations reported in Table VI.1.1 are indicative of the degree of dispersion in lot-average characteristics across lots. They do not measure the degree of dispersion in quality characteristics across cattle within a typical lot. The data set does not contain information on the uniformity of cattle within lots.

[12]This approach explains the market prices of a commodity with multiple quality characteristics in terms of the values of these characteristics. An example of this methodology is provided by Ladd and Martin.

the lots of live-weight priced fed cattle purchased on the spot market. For each plant, we perform an OLS regression of the prices of these lots on variables indicative of the lots' quality (like those summarized in Table VI.1.1) and a selection of other variables which may influence price (like the week of purchase). We then use the regression results to "evaluate," not only the live-weight-priced, spot-market-purchased lots that comprised the samples used for estimation, but also the lots of fed cattle procured by other means. A comparison of the evaluations across procurement methods provides one way to assess the "quality" of lots of fed cattle procured by alternative methods.

In more detail: For each plant separately, we use the sample of live-weight-priced, spot market fed cattle lots to estimate a price function. That is, we estimate a regression of the following form[13]:

$$\begin{aligned} PRICE_i = {} & a_0 + a_1\, HEAD_i + a_2\, YIELD_i + a_3\, PCTPC_i + a_4\, PCTYG13_i + \\ & a_5\, MILES_i + a_6\, MILES2_i + a_7\, HEIFER_i + a_8\, MIX_i + a_9\, AWS_i + \\ & a_{10}\, AW2S_i + a_{11}\, AWH_i + a_{12}\, AW2H_i + a_{13}\, AWM_i + a_{14}\, AW2M_i + a_{15}\, MON_i + \\ & a_{16}\, TUE_i + a_{17}\, WED_i + a_{18}\, THU_i + a_{19}\, WKEND_i + d_1\, PW1_i + d_2\, PW2_i + \ldots + \\ & d_{66}\, PW66_i + \varepsilon_i \end{aligned} \qquad (1)$$

where the "i" subscript indexes lots of cattle, ε_i represents the influence of factors not-otherwise-accounted-for (because they are not reflected in the data set), and the definitions of the variables in the regression are as follows:

PRICE = the price of the lot of cattle measured in either one of two ways: the FOB feedyard price in $/cwt. on a live-weight basis; or the "delivered hot cost," which represents acquisition cost plus transportation cost, in $/cwt. on a carcass-weight basis.
HEAD = number of cattle in the lot (head).
YIELD = the lot's total hot weight divided by total live weight (%).
PCTPC = percentage of the lot grading prime or choice (%).

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[13]The data set recorded 24,425 spot market purchases of lots of fed cattle by the four Texas plants combined. Only those lots that were priced on a live-weight basis were used in this analysis. Several other lots were dropped because of incomplete or obviously incorrect data. For example, approximately 800 lots had entries for total delivered cost (which should include transport cost) that were less than or equal to the entries for FOB feedyard cost (which should exclude transport cost). The price function regressions were run on a plant-by-plant basis with the following numbers of observations:

PCTYG13 = percentage of the lot achieving yield grades 1, 2, or 3 (%).
MILES = the distance the cattle were shipped to the plant (miles).
MILES2 = the square of the distance the cattle were shipped to the plant (miles^2).
HEIFER = a dummy variable equal to 1 if the lot consists of heifers, and equal to 0 otherwise.
MIXED = a dummy variable equal to 1 if the lot consists of a mixture of steers and heifers, and equal to 0 otherwise.
AWS = the lot's average carcass weight, if the lot consists of steers; equal to 0 otherwise (lb.).
AW2S = the square of the lot's average carcass weight, if the lot consists of steers; equal to 0 otherwise (lb.^{2}).
AWH = the lot's average carcass weight, if the lot consists of heifers; equal to 0 otherwise (lb.).
AW2H = the square of the lot's average carcass weight, if the lot consists of heifers; equal to 0 otherwise (lb.^{2}).
AWM = the lot's average carcass weight, if the lot consists of a mixture of steers and heifers; equal to 0 otherwise (lb.).
AW2M = the square of the lot's average carcass weight, if the lot consists of a mixture of steers and heifers; equal to 0 otherwise (lb.^{2}).
MON = a dummy variable equal to 1 if the lot was purchased on a Monday, and equal to 0 otherwise.
TUE = a dummy variable equal to 1 if the lot was purchased on a Tuesday, and equal to 0 otherwise.
WED = a dummy variable equal to 1 if the lot was purchased on a Wednesday, and equal to 0 otherwise.
THU = a dummy variable equal to 1 if the lot was purchased on a Thursday, and equal to 0 otherwise.
WKEND = a dummy variable equal to 1 if the lot was purchased on a weekend, and equal to 0 otherwise.
PW1, PW2, . . ., PW66 = a set of dummy variables identifying the purchase weeks represented in the sample.

Tables VI.1.2 and VI.1.3 report the results of this regression, for each of the two definitions of the PRICE variable, in the case of The results for other plants, though not reported, were similar.

Denote the OLS estimates of the regression coefficients by $\hat{a}_0$, $\hat{a}_1$, $\hat{a}_2$, . . ., etc. For each of the lots of live-weight-priced, spot market cattle, we used the coefficient estimates to form an index of lot quality in the following manner:

$$\hat{PRICE}_i = \hat{a}_0 + \hat{a}_1 HEAD_i + \hat{a}_2 YIELD_i + \hat{a}_3 PCTPC_i + \hat{a}_4 PCTYG13_i +$$

$$\hat{a}_5 MILES_i + \hat{a}_6 MILES2_i + \hat{a}_7 HEIFER_i + \hat{a}_8 MIX_i + \hat{a}_9 AWS_i + \qquad (2)$$

$$\hat{a}_{10} AW2S_i + \hat{a}_{11} AWH_i + \hat{a}_{12} AW2H_i + \hat{a}_{13} AWM_i + \hat{a}_{14} AW2M_i ,$$

where $HEAD_i$, $YIELD_i$, . . ., etc., were the values of these variables for the i^{th} lot. Because the terms in the purchase-day-of-week and purchase-week-of-sample variables are omitted in the formula for $\hat{PRICE}$, the result is an estimate of the price that a lot of cattle with characteristics identical to those of the i^{th} lot, *would have brought* had it been sold on the spot market, on a live-weight-priced basis, on Friday (the "base" purchase day; that is, the one for which no dummy variable was included in the model) of the week of January 29, 1995 (the "base" purchase week). This estimate can be interpreted as a scalar index of lot "quality" that relies on the market's implicit evaluation of quality attributes, as reflected in the purchase price, but controls for any tendency for prices to vary, for reasons unrelated to quality, across days of the week or over weeks of the sample. The summary statistics for this index (mean, standard deviation, etc.) within the sample of live-weight-priced, spot market cattle, describe the distribution of quality among lots of cattle obtained by that particular procurement method.

The characteristics of a lot of cattle procured by another method (marketing agreement, contract, or packer fed) can also be substituted into equation (2) to obtain an estimate of the price that an otherwise-identical lot of cattle *would have brought* had it been sold on the spot market, on a live-weight-priced basis, on Friday of the week of January 29, 1995. The result; $\hat{PRICE}$ for a marketing agreement lot, say; is a lot "quality" index that is directly comparable to the $\hat{PRICE}$ quality indices for cattle that actually were purchased on the spot market. The summary statistics for the quality index within the samples of lots procured by other methods provide a representation of the overall quality of cattle obtained by those methods.

As mentioned above, for each plant, and for each definition of the dependent variable, a price regression of the form of equation (1) was estimated. The results were used to develop $\hat{PRICE}$ quality indices for every lot of fed cattle. The summary statistics for the distributions of these indices, within samples corresponding to a given procurement method, were then calculated and are reported in Table VI.1.4.

Overall, the results show evidence of relatively little systematic variation in average lot quality across procurement methods.[14] For example, based on the FOB feedyard price regression results, the mean of the quality index for marketing agreement cattle is slightly greater than the mean for spot market cattle in the plants; but this ordering is reversed in each of these cases when the quality index is based on the delivered hot cost regression results. Again using the FOB-feedyard-based quality index, spot market cattle appear to be of slightly higher quality than contract cattle in all four plants. But, in terms of the delivered-hot-cost-based index, contract cattle appear to be slightly better than spot cattle For both indices, the mean value for spot market lots exceeds the corresponding mean value for packer fed lots in But in one index suggests that spot market lots are of higher quality than packer-fed lots, and one suggests the opposite.

In the range between the minimum and maximum lot quality is greater among spot market lots than among contract, marketing agreement, or packer fed lots. Interestingly, however, the standard deviations of the distributions of quality among contract and marketing agreement lots are often greater than the standard deviation among spot market lots. This suggests that the samples of spot market lots typically contain more extreme quality "outliers" than do the samples corresponding to other procurement methods. But spot market lot quality does not appear to be more variable "on average" than contract or marketing agreement lot quality.

VI.2 Quality-adjusted Price Differences

Another issue of preliminary interest is whether the prices paid for lots of cattle procured by different methods appear to differ, once appropriate adjustments are made

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[14]It should be emphasized that, in this analysis, we are implicitly treating the size of the lot and the distance the lot is shipped to the plant as aspects of lot "quality." As Table VI.1.1 shows, these characteristics do have some tendency to vary systematically across procurement methods, and that variation contributes to differences in Table VI.1.4's procurement-method-specific means of the quality index through the market's implicit valuation of lot size and distance shipped. In using the product characteristic price function to evaluate lots, it is also possible to control for systematic variation in lot size and distance. Had we taken this approach, a comparison of the resulting quality index means would have been reflective of variation, across procurement methods, of the more conventional dimensions of "quality:" yield, quality grade, average carcass weight, etc.

for any systematic differences in quality.[15] Our strategy for investigating this issue is to carry out a multiple regression analysis of the sample of lots of fed cattle purchased by the four Texas plants during the investigation period. The dependent variable will be the price paid for each lot.[16] Independent variables will include a set of lot quality indicators, other factors which could conceivably influence price (such as the identity of the purchasing plant and the week of purchase) and a set of dummy variables which, for each plant separately, identify the procurement method. Estimates of the coefficients of these dummy variables should then reveal whether there are differences in "quality-adjusted price" across procurement methods.

In more detail: The dependent variable in the price regression is

DPRICE = the delivered hot-cost of the lot, which includes both acquisition and transport cost, on a carcass-weight basis ($/cwt).[17]

The menu of independent variables includes:

HEAD = number of cattle in the lot (head).
YIELD = the lot's total hot weight divided by total live weight (%).
PCTPC = percentage of the lot grading prime or choice (%).
PCTYG13 = percentage of the lot achieving yield grades 1, 2, or 3 (%).
MILES = the distance the cattle were shipped to the plant (miles).
MILES2 = the square of the distance the cattle were shipped to the plant (miles^2).
HEIFER = a dummy variable equal to 1 if the lot consists of heifers, and equal to 0 otherwise.
MIXED = a dummy variable equal to 1 if the lot consists of a mixture of steers and heifers, and equal to 0 otherwise.
CARCASS = a dummy variable equal to 1 if the lot was priced on a carcass-weight basis, and equal to 0 otherwise.
AWS = the lot's average carcass weight, if the lot consists of steers; equal to 0 otherwise (lb.).

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[15]In this section's comparisons of prices across procurement methods, we make an effort to control for quality variation across lots even though the analysis based on the product characteristic approach in section VI.1 did not show clear evidence of systematic differences in quality among spot market, contract, and marketing agreement cattle.

[16]Packer fed cattle are excluded from this analysis because the "prices" reported for these lots are merely internal transfer prices that bear no necessary relation to observed market prices.

[17]Because no FOB feedyard prices were available for cattle procured by other than spot market means, it was necessary to base this regression on delivered price.

AW2S = the square of the lot's average carcass weight, if the lot consists of steers; equal to 0 otherwise ($lb.^2$).

AWH = the lot's average carcass weight, if the lot consists of heifers; equal to 0 otherwise (lb.).

AW2H = the square of the lot's average carcass weight, if the lot consists of heifers; equal to 0 otherwise ($lb.^2$).

AWM = the lot's average carcass weight, if the lot consists of a mixture of steers and heifers; equal to 0 otherwise (lb.).

AW2M = the square of the lot's average carcass weight, if the lot consists of a mixture of steers and heifers; equal to 0 otherwise ($lb.^2$).

a dummy variable equal to 1 if the lot was purchased by the plant, and equal to 0 otherwise.

a dummy variable equal to 1 if the lot was purchased by the plant, and equal to 0 otherwise.

a dummy variable equal to 1 if the lot was purchased by the plant, and equal to 0 otherwise.

M a dummy variable equal to 1 if the lot was a marketing agreement purchase by the plant, and equal to 0 otherwise.

M a dummy variable equal to 1 if the lot was a marketing agreement purchase by the plant, and equal to 0 otherwise.

M a dummy variable equal to 1 if the lot was a marketing agreement purchase by the plant, and equal to 0 otherwise.

M a dummy variable equal to 1 if the lot was a marketing agreement purchase by the plant, and equal to 0 otherwise.

C a dummy variable equal to 1 if the lot was a contract purchase by the plant, and equal to 0 otherwise.

C a dummy variable equal to 1 if the lot was a contract purchase by the plant, and equal to 0 otherwise.

C a dummy variable equal to 1 if the lot was a contract purchase by the plant, and equal to 0 otherwise.

C a dummy variable equal to 1 if the lot was a contract purchase by the plant, and equal to 0 otherwise.

The list of independent variables also included a set of dummy variables identifying the week of the sample in which the lot was killed.[18]

The results of ordinary least squares estimation of this regression are reported in Table VI.2.1. Because we are primarily concerned at this stage with the possibility of quality-adjusted differences in price across procurement methods, our attention focuses on the estimates of the coefficients attaching to the dummy variables identifying

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[18]Because there is no definition of "purchase day" that is meaningful across lots of cattle procured by spot and non-spot means, purchase-day-of-week dummy variables could not be included in this regression.

procurement methods on a plant-by-plant basis.[19] The estimates of the coefficients of M , M , M , and M represent the differences in delivered hot costs between a marketing agreement lot of cattle and an otherwise identical lot purchased on the spot market by plants, respectively. These estimated quality-adjusted price differences are all significant, both statistically[20] and in terms of economic significance. The estimates of the premia paid to marketing agreement cattle range from a low of $0.52/cwt. to a high of $2.26/cwt. .[21] For comparison: The overall sample mean of delivered hot cost, the regression's dependent variable, is $102.12/cwt.

The estimates of the coefficients of C , C , C , and C represent the differences in delivered hot costs between a forward contract lot of cattle and an otherwise identical lot purchased on the spot market by the plants, respectively. The point estimate of the quality-adjusted price difference for is small in magnitude (-$0.01/cwt.) and statistically insignificant. The estimated price differences for the other three plants are all statistically significant at the 0.01% level and range from a low of $2.00/cwt. to a high of $2.46/cwt .[22]

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[19]The role of the other variables in this regression is to control for the price effects of variation in lot attributes other than procurement method. We will interpret estimates of the coefficients of these variables in our discussion of the results of similar regressions carried out elsewhere in this report.

[20]The estimates of the coefficients of are significantly different from zero at the 0.01% level.

[21]Actually, these estimates confound two separate effects: the "marketing agreement effect" and the "formula pricing effect." The data do not provide a capability to estimate these two effects separately because all marketing agreement cattle were priced on a (live-weight or carcass-weight) formula basis whereas all spot market cattle and virtually all forward contract cattle (99.3% of the lots) were priced on a (live-weight or carcass-weight) non-formula basis.

[22]The regression reported in Table VI.2.1 was also estimated on a plant-by-plant basis using the subsamples The table below reports the resulting estimates of the price premia paid to marketing agreement and forward contract cattle, relative to spot market cattle. There are some appreciable differences in magnitudes between these estimates and those obtained in the regression using the pooled data set. The one qualitative difference of note is that, judging by the results of the plant-by-plant regressions, appears to pay a quality-adjusted premium on forward contract cattle too.

These results suggest that the four Texas plants paid significant quality-adjusted price premia for marketing agreement cattle relative to cattle purchased on the spot market.[23] These estimated premia could be a reflection of the transaction cost savings experienced by packers when they employ marketing agreements. Or they could be an artifact of our inability to control for some potentially important cattle quality attributes, such as the uniformity of cattle within a lot.

Our results also suggest that three of the four plants paid significant quality-adjusted price premia for forward contract cattle relative to cattle purchased on the spot market.[24] It is possible that these apparent premia were simply due to futures contract performance which, during the period of investigation, happened to favor basis forward contract sellers over buyers. For example, if it were the case, over this relatively brief period, that futures market prices tended to overestimate spot prices at the contract expiration date, one would expect a corresponding tendency for prices of lots of forward contract cattle to exceed prices of lots of spot market cattle when compared across lots delivered the same week.

A careful investigation of this possibility is hampered by the fact that the data on lots of forward contract cattle do not include the basis bids, or the futures contract month, or the date on which the feeder priced the cattle, or even whether all contracts were basis forward contracts as opposed to fixed price contracts. A preliminary investigation can proceed, however, through reliance on some plausible guesses. We

Variable	Estimate	t-statistic
M	1.565165	4.809
M	1.520932	15.173
M	1.706804	2.322
M	1.400933	2.876
C	1.678630	18.630
C	2.317293	22.837
C	2.665420	3.617
C	1.058751	2.166

[23]Our findings contrast quite sharply with those of Ward *et al.* Using a similar method but different data, they estimated the price premium paid to marketing agreement cattle to be on the order of only $0.07/cwt. to $0.10/cwt. (on a live-weight basis).

[24]This finding also contrasts sharply with the results reported in Ward *et al.* They found evidence that packers actually paid *lower* quality adjusted prices for forward contract cattle than for spot market cattle.

assume that all forward contract cattle were sold on basis forward contracts. We assume that lots of forward contract cattle that were delivered during weeks entirely within a futures contract month (February, April, June, August, October, and December), or a month preceding a futures contract month, were sold on contracts that tied sale price to the futures price for that month. Lots delivered in weeks that straddled the end of a futures contract month were assumed to have been sold on contracts tied to the price of the next futures contract.[25]

Given these assumptions, it is the performance of the February 1995 through June 1996 live cattle futures market contracts that is of relevance for this study. For each of these contracts, we considered the daily average price quotes on the contract for days from the first day of the contract month back through 120 days prior to that date.[26] We then took the difference between the average of these daily prices and the price on the first day of the contract month as a very rough estimate of the typical change in the futures price between the date of pricing of the forward contract cattle and the date of delivery. Finally we calculated a weighted average, across futures contracts, of these price differences with the weights taken to be the proportions of the sample's forward contract cattle assumed to be sold on contracts tied to each of the futures contracts.

The result of these calculations is a weighted average *decrease* in the futures price by $1.61/cwt. on a live-weight basis, the equivalent of roughly $2.56/cwt. on a carcass-weight basis. Subject to the validity of the many assumptions we have made, this result can be interpreted as the representative change in futures prices between the date when forward contract cattle were priced and the date when they were delivered. The fact that the figure is roughly equal to the estimated forward contract vs. spot quality-adjusted price differences estimated for three of the plants suggests a possible source of these "premia:" They may simply reflect the benefit forward contract sellers received as a result of futures contract prices that tended, on average, to overestimate future spot prices.

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[25]For example, lots delivered during weeks falling entirely within the months of May and June were assumed to be priced according to the price of the June futures contract. Lots delivered in a week including both June 30th and July 1st were assumed to be priced according to the price of the August futures contract.

[26]In the case of the February 1995 and April 1995 contracts, we went back only 29 days and 88 days, respectively, because earlier data were not readily available to us at the time this calculation was performed.